Assessing Potential for Using Zinc Phosphide Bait to Control Nutria on Louisiana Coastal Marsh

Dale L. Nolte
USDA APHIS Wildlife Services, National Wildlife Research Center, Olympia, Washington
Amy E. Barras
USDA APHIS Wildlife Services, National Wildlife Research Center, Starkville, Mississippi
Suzanne E. Adams
USDA APHIS Wildlife Services, National Wildlife Research Center, Olympia, Washington
R. Greg Linscombe
Louisiana Department of Wildlife and Fisheries, New Iberia, Louisiana
Dwight J. LeBlanc
USDA APHIS Wildlife Services, Port Allen, Louisiana

ABSTRACT: Nutria are large semi-aquatic rodents native to South America. Nutria were first introduced to the United States because of their fur, and some populations remain economically important to the fur industry. Accidental and intentional releases have permitted them to establish in wetlands across the United States. Burrowing and foraging by nutria often inflict severe damage and can be devastating to native vegetation. Nutria are recognized as at least a contributing factor to the decline of native Louisiana coastal marsh. Management plans to reduce impacts require reducing nutria populations, or where possible, eliminating them from target sites. At present, public hunting and trapping encouraged by an incentive payment program are primary approaches to reduce unwanted populations. However, alternative tools, including toxins, need to be assessed for possible use. Previous studies assessing zinc phosphide baiting have addressed nutria control on open waterways. Considerable data can be extrapolated from these prior studies and applied to baiting on coastal marshes. However, animals may respond differently to baits and baiting strategies applied to coastal marsh. We conducted a series of studies to assess the potential for developing a feasible strategy to suppress nutria populations with zinc phosphide bait on Louisiana coastal marsh. Tetracycline and metallic flakes show promise as tools for studying nutria foraging behavior. Nutria activity on rafts was marginal, probably because of their access to native vegetation. Simple audio, olfactory, and ocular cues tested as attractants to entice nutria to bait station showed marginal efficacy. Olfactory stimuli demonstrated the most potential for developing future attractants.

KEY WORDS: attractants, baiting, marsh, *Myocastor coypus*, nutria, rodent control

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INTRODUCTION

Nutria (*Myocastor coypus*), a large semi-aquatic rodent native to South America, have been introduced around the world, primarily for their fur (Guichon et al. 2003). They were first brought to the United States as early as 1899 (Ashbrook 1948). Their dispersal was encouraged by promoters selling them as "weed cutters" and by fur farmers (Willner 1982). Through escapes and intentional releases, nutria spread and they continue to exist in 15 states (Carter and Leonard 2002). Their adaptability enables them to survive in most aquatic habitats in warm or mild climates (Evans 1970). Nutria are opportunistic foragers consuming a variety of aquatic plants (Willner 1982). Where nutria exist, their high reproductive capacity enable their populations to expand rapidly (Nowak 1991). They reach sexual maturity as early as 4 months and breed year-round. A post-parturition estrus permits them to produce 3 litters in less than 14 months. Generally there are 4 pups per litter, but litters as high as 13 pups have been reported, and pups can survive without maternal care after only 5 days. Their ability to adapt, their voracious appetite, and their high reproductive potential, are primary factors why nutria are recognized as one of the top 100 worst invasive species in the world (Lowe et al. 2002).

Nutria damage to Louisiana coastal marsh has been an increasing concern (Linscombe 2000). Herbivory by nutria is recognized as at least a contributing factor to the decline of native Louisiana coastal marsh, declining vegetative biomass, and changing plant communities (Shaffer et al. 1992, Grace and Ford 1996, Evers et al. 1998, Ford and Grace 1998, Visser et al. 1999). A nutria's daily intake is roughly equivalent to 25% of its body weight (Willner 1982), and typical feeding behavior is to continue foraging in an area until it is denuded (Mach 2002). Their uprooting of plants and repeated foraging can be detrimental to plant communities. Vegetation surveys indicate that nutria have already impacted over 100,000 acres of Louisiana marsh (Kinler et al. 2001). These impacts are causing conversion of vegetated tracts to open water, exposing the substrate to tidal scour and erosion (Linscombe 2001). Further, continuous feeding by nutria may be undermining floating mats. Some mats that were several feet thick during the early 1900s have declined over the years until they now are only a few inches thick (Harris and

Chabreck 1958, Visser et al. 1999).

The Louisiana Department of Wildlife and Fisheries (LDWF) is examining multiple approaches for reducing nutria's detrimental impacts to native marsh (see Mach 2002). Management plans to reduce their impacts typically involve population reduction or eradication (Schitoskey et al. 1972, Gosling and Baker 1989). An incentive payment program to encourage public hunting and trapping has significantly increased nutria harvest over the past few years (Mach 2002). The program's goal is removal of 400,000 animals from nutria damaged areas every year. This number approximates the annual nutria harvests when fur prices were high and damage to coastal marsh was minimal. Although the incentive program appears to be working, the LDWF continues to evaluate feasibility of alternative methods. Schitoskey et al. (1972) reported that trapping was effective for small nutria populations but recommended toxicants, such as zinc phosphide, for large-scale control efforts. Placing zinc phosphide-treated bait on rafts has been an effective method to reduce nutria populations on canal and other open waterways (LeBlanc 1994).

We conducted a series of studies to assess feasibility of baiting on coastal marsh and to assess possible approaches for attracting animals to bait stations. Specific objectives were: 1) determine temporal residues of tetracycline and metallic flakes to monitor nutria foraging activity; 2) determine preferred foods for bait on coastal marshes; 3) determine nutria activity on rafts containing bait on coastal marshes; 4) determine potential of audio, olfactory, and ocular stimuli to attract nutria to bait stations; and 5) determine susceptibility of marsh captured nutria to zinc phosphide-treated bait.

METHODS

Study Site

The field portion of the study was conducted on Lake Salvador near Luling, Louisiana. Rafts were placed in a free-floating marsh on the LDWF Salvador Wildlife Management Area located along the northwest corner of the lake. The surface of a well-developed mat floats about 5 cm above the water and roots develop in the upper 5 cm of substrate (Sasser et al. 1996). Predominant plants on our study site were hydrocaudal, eleocharris, and bidens. Nutria used in pen studies were captured in vicinity of the research rafts. Experimental procedures were conducted in pens near New Iberia, Louisiana, or in a T-maze constructed on site.

Subjects

Nutria live-captured by LDWF personnel were transported to pens near New Iberia, Louisiana. Subjects were group-housed (5 to 7 per pen) in roof-covered cinder-block pens (2 × 5 m). A two-chambered covered nest area was located at one end of the pen, and a depression at the other end served as a water trough. The trough (1 × 2 m) was approximately 50 cm deep, adequate for nutria to submerge themselves. Pens were cleaned daily. Animals were given a daily ration of rodent blox, along with sweet potato pieces, carrots, and apple slices. Although food consumption was not measured, its consumption was observed and general notes recorded. They also had free access to water.

Procedures

Experiment 1

Determining bait consumption by individual animals in the field is not possible. Thus, we wanted to assess potential markers that could be applied to bait which would later enable us to determine whether an animal had previously ingested bait. The objective of the first experiment was to determine how soon after ingesting bait animals would show biological markers, and how long markers would persist once nutria ceased bait consumption. The 3 markers tested were tetracycline (Sigma Aldrich), metallic flakes (Elmer's Glitter, Elmer's Products Inc., Columbus, OH), and powders (radiant fluorescent pigments, Radian Color, Richmond, CA). Sweet potatoes were used as the carrier during this experiment. When ingested, tetracycline is absorbed and causes discoloration of the teeth (Matson and Kerr 1998). Metallic flakes have been used to assess feeding behavior of rats (Fall and Johns 1987). Likewise, fluorescent powders have been used to study foraging behavior of voles (Hovland and Andreassen 1995). Markers were first mixed with corn oil (tetracycline 8 g/L corn oil; metallic flakes 6 g/L corn oil; powders 1.5 g/100 g corn oil), and then applied to bait by pouring the mix over sweet potatoes and stirring until all parts were evenly covered.

One group of animals was offered bait containing tetracycline, metallic flakes, and powder. Bait acceptance, however, was very poor and subsequent trials indicated nutria rejected the powder-treated food. Therefore, another group was offered tetracycline treated food containing metallic flakes. On Day 1 they were given bait containing red flakes, on Day 2 bait was treated with green flakes, and blue flakes were used on the third day. Animals ($n = 5$) were sacrificed on Days 2 through 6, a tooth extracted, and their internal organs were examined to assess marker presence. Teeth were sent to Matson's Laboratory (Milltown, MT) to evaluate whether they contained tetracycline.

Experiment 2

Nutria response to rafts and their relative preference among baits was determined in an experiment conducted from May 21 to June 8, 2003. Eight bait stations were established in an area known to have high nutria populations. Four stations were placed directly on the floating marsh in areas with nutria trails, and the other 4 stations were located on open water areas. Open water was regularly dispersed across the marsh where the floating mat had broken apart. The rafts were distributed in 2 rows with 4 rafts each, located at 0.75- to 1-km intervals. Rafts placed on the floating mat were interspersed with rafts placed in open water. Rafts were constructed as described by LeBlanc (1994). In brief, styrofoam sheets (7.62 cm thick) were sandwiched between two 3/4-inch 4- × 8-ft plywood sheets (1.9 cm thick, 1.22 × 2.44 m) and bolted together. A lip was created around the platform edge and twice across the center, dividing the platform into 3 equal sections (0.81 × 1.22 m) by affixing 2 × 4's at the appropriate places.

Platforms floated such that their top was approximately 7.5 to 10 cm above the water surface.

Feasible baits were selected based on prior work (Evans 1970), accessibility, and cost. Tested baits included carrots, sweet potatoes, and apples. Before placing baits on rafts, they were cut into roughly 5-cm segments and covered in corn oil. The three baits were then placed on rafts in equal amounts by weight (10 kg). Baits were not treated with zinc phosphide. Consumption was determined 3 times a week by weighing the amount of bait remaining during each visit. Although not weighed, the response of captive nutria to these foods was observed to determine if they demonstrated a preference for one item over the others. All foods were fed at roughly the same time and the order that items disappeared was noted.

Experiment 3

Once nutria begin to feed at a site, they tend to continue feeding there until the food is depleted (Mach 2002). Therefore, if they can be attracted to a raft and enticed to eat bait, then they are likely to continue feeding at the bait station. We conducted the third experiment to determine whether attractants could be used to entice nutria to bait stations. Nutria responses to an audio, an olfactory, and an ocular stimulus were assessed in a T-maze. The T-maze was constructed from wire panels (1 m high), with bars inserted below to prevent digging, and covered in plastic to form 1-m-wide solid-walled corridors (Figure 1). The base of the maze was 4 m long from entry to choice-point. Each arm of the maze was 18 m from choice-point to a goal box on either end. The auditory stimulus was a recording of calls emitted by nutria. The recorder playing the calls was placed a couple meters beyond the respective goal box. Olfactory cue was a mixture of nutria trough water that contained some feces and urine. The mixture was sprayed on the ground from the start point to a goal box. The ocular stimulus was a live-nutria effigy confined to a small cage. The caged nutria was placed 5 m down the respective maze-arm, rather than in the goal box.

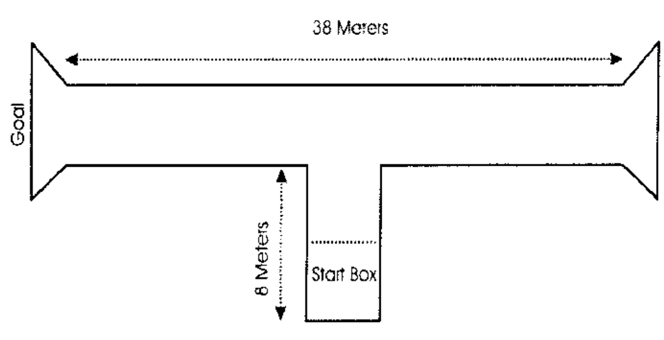

Figure 1. The T-maze used in trials to assess nutria response to attractants.

The maze enabled us to assess nutria responses to each stimulus in a series of two-choice tests. Each test was repeated 4 times, in 2 sets of paired tests. Each stimulus was randomly assigned an arm for the first trial within a pair and then placed in the opposite arm during the second trial. A baseline test (4 trials), with no stimuli present, was conducted first to determine whether nutria exhibited a side response bias. Otherwise, the order which stimuli were tested was random. The ocular test was conducted twice, once with a male effigy (4 trials), and once with a female effigy (4 trials). All trials were conducted in the morning or late evening when nutria are normally more active.

The same 15 nutria (11 females and 4 males) were individually evaluated during each trial. An observer started timing responses when the nutria was released into the start box. The observer recorded the elapsed time for a nutria to exit the start box, to reach the choice-point, and then to reach a goal box. If nutria failed to reach the choice-point within 5 minutes, a second observer entered the maze, proceeding halfway (2 m) down the base. Trials were concluded when a nutria entered a goal box or after 15 minutes. During effigy trials, goal lines were moved to 4 m on either side of the choice-point. The primary observer also recorded the first direction a nutria turned at the choice-point, if it reversed directions, and any behaviors exhibited (e.g., marking behavior, sniffing walls). After each trial run, the walls and floor of the base and the first 6 m of each arm were washed with a spray nozzle to remove possible odor residues.

A chi-square goodness of fit test was used to assess whether nutria differentiated between goal boxes when a stimulus was present. Male and female data were combined for analysis. Expected values were calculated as 7.5, equivalent to half the nutria approaching a stimulus while the other half approached the opposite goal box. Each trial was assessed independently, and differences were considered significant at the 0.05 probability level.

Experiment 4

The last experiment determined susceptibility of marsh-captured nutria to zinc phosphide-treated bait. At the conclusion of maze tests, 15 nutria were offered zinc phosphide (0.67%)-treated sweet potatoes. These nutria had been fed sweet potatoes daily for several weeks prior to baiting. Animals were not offered alternative foods during baiting.

RESULTS

Experiment 1

Tetracycline-marked teeth were identified in 40% of the animals sacrificed on Day 2. The percentage increased to 60% from animals collected on Days 3 and 4. After 5 days exposure to the treated bait, 80% of the animals had marked teeth.

Immediately after ingestion, metallic flakes appeared in the stomach (Figure 2). Red flakes persisted in the stomach until Day 3, with a few flakes remaining in one animal on Day 4. Green and blue flakes were present in the stomach on Days 3 and 4. No flakes persisted in the stomach after Day 4, regardless of when the flakes were applied. A few metallic flakes appeared in the intestine the same day they were fed to nutria (Figure 3). However, metallic flakes were more prevalent in the intestine 2 or 3 days after nutria ingested them. Although a few flakes remained through Day 6, again flakes became less common after Day 4 regardless of treatment. A few flakes appeared in feces the day they were ingested (Figure 4). Although some flakes continued to be present in nutria feces 6 days later, they were most common the second and third day after treatment.

Experiment 2

Based on bait consumption and nutria indicators (e.g., feces, chew marks), only 1 of the 8 rafts was routinely visited by nutria. Most of the baits desiccated in the heat, and this water loss caused a decrease in weight. However, it was apparent the bait weight loss was not due to nutria; no tooth marks were seen, and the original integrity of bait piles remained undisturbed. Bait consumption on the raft visited by nutria increased over time (Figure 5). Greater amounts of sweet potato were taken than carrots or apples. This apparent nutria preference for sweet potato was repeated in the pen studies. Once nutria were familiar with all foods, when fed they invariably ingested sweet potato first, then ate the apples and carrots. Rodent blox was always consumed last, after the fresh baits were gone.

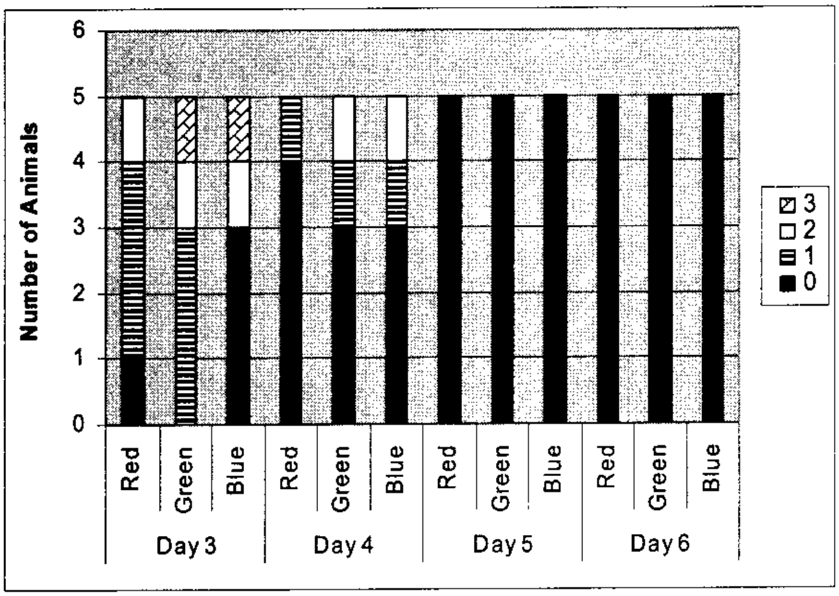

Figure 2. Quantity of metallic flakes identified in the nutria stomachs collected on Days 3 through 6. Nutria were fed bait treated with red metallic flakes on Day 1, green flakes on Day 2, and blue flakes on Day 3. A score of 0 indicates no metallic flakes were present, 1 indicates 1 - 2 flakes, 2 indicates 3 - 4 flakes, and 3 means more than 4 flakes.

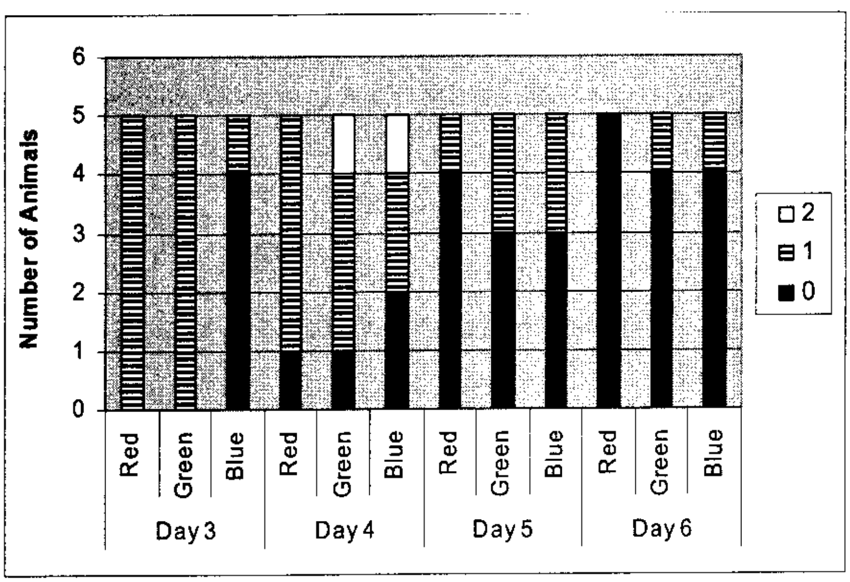

Figure 3. Quantity of metallic flakes identified in the nutria lower intestines collected on Days 3 through 6. Nutria were fed bait treated with red metallic flakes on Day 1, green flakes on Day 2, and blue flakes on Day 3. A score of 0 indicates no metallic flakes were present, 1 indicates 1 - 2 flakes, and 2 indicates 3 - 4 flakes.

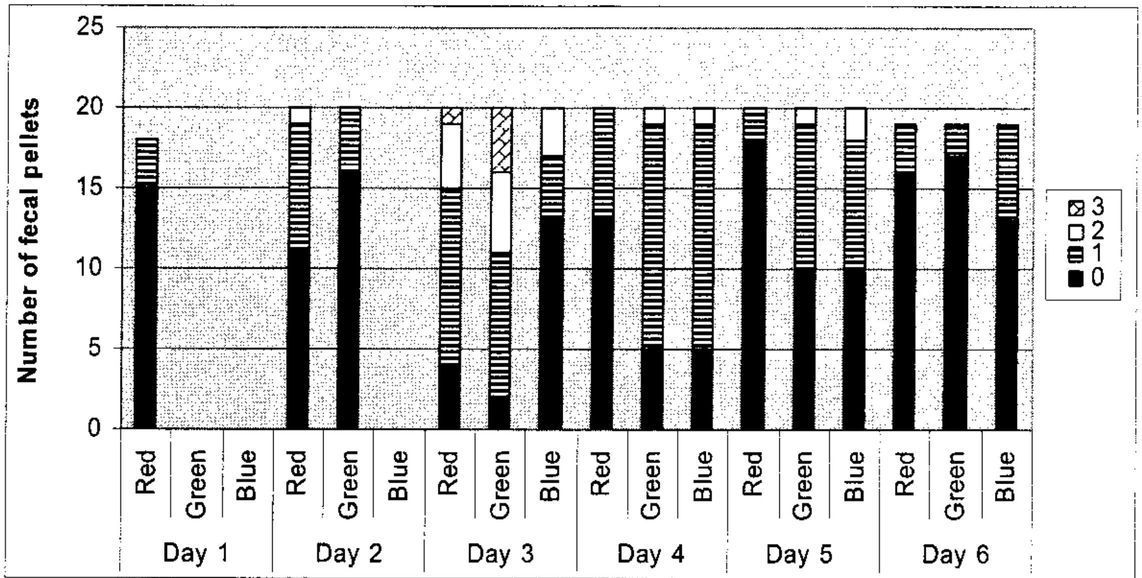

Figure 4. **Quantity of metallic flakes identified in the nutria feces deposited in pens on Days 3 through 6. Nutria were fed bait treated with red metallic flakes on Day 1, green flakes on Day 2, and blue flakes on Day 3. A score of 0 indicates no metallic flakes were present, 1 indicates 1 - 2 flakes, 2 indicates 3 - 4 flakes, and 3 means more than 4 flakes.**

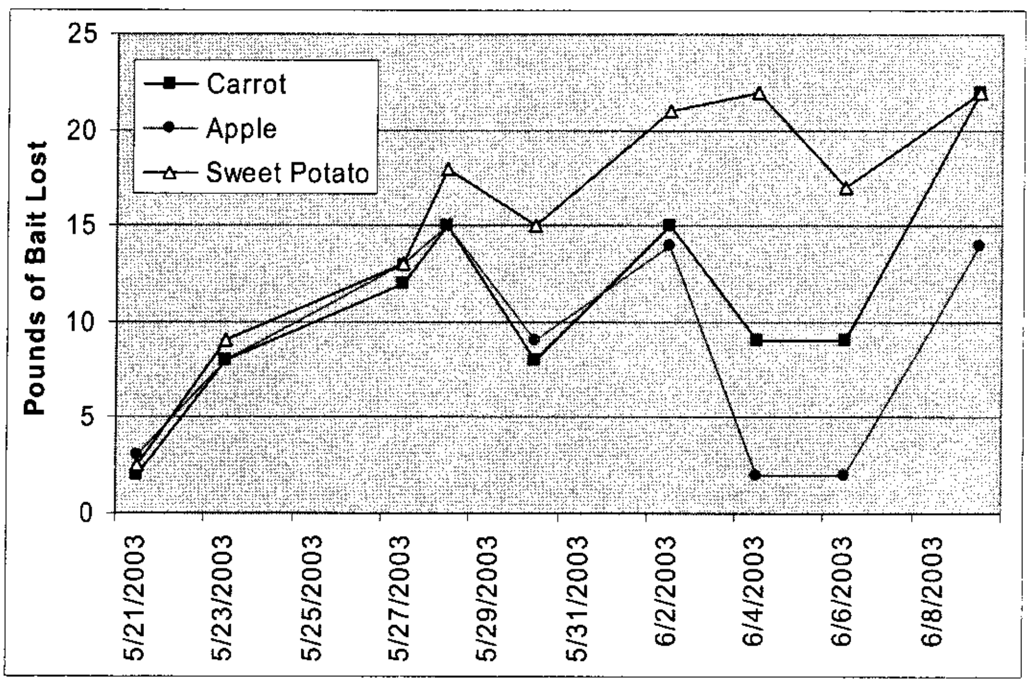

Figure 5. **Amounts of carrot, apple, and sweet potato missing from a raft located in floating marsh on the Salvador Wildlife Management Area near New Iberia, Louisiana.**

Experiment 3

Overall, nutria responses during trials generally did not significantly differentiate ($P > 0.05$) between goals boxes with or without stimulus. One exception was that they followed the olfactory trail to a goal box during the first olfactory trial. Nutria, however, did exhibit some interesting tendencies. They did not demonstrate a direction bias during baseline trials, but times to reach a goal box increased with subsequent trials. There was a tendency for nutria to avoid the audio stimuli, or to fail to reach either goal box, when pre-recorded calls were played. Trial times also were consistently long during the audio test. The fastest mean time to reach a goal box with a stimulus occurred during the first olfactory trial. Both male and female nutria appeared indifferent in their responses during ocular trials, regardless whether the effigy was male or female. Marking behavior tended to be infrequent, except during ocular trials, when approximately one-third of the animals urinated or rubbed against a maze wall.

Experiment 4

Twelve nutria offered zinc phosphide-treated sweet potatoes died within 24 hours, while 3 nutria survived.

DISCUSSION

Tetracycline and metallic flakes appeared to be reliable indicators of bait ingestion. Nutria readily ingested sweet potatoes treated with tetracycline and metallic flakes. Baits treated with powders were rejected by nutria. Tetracycline was detected in nutria teeth after only 2 days post treatment. Its reliability to mark treated animals increased with time; 80% of the treated animals were positive after 5 days. Generally, tetracycline is used as a long-term marker with at least several weeks lapsing between feeding it to animals and subsequent tooth collection (Matson and Kerr 1998).

Ingested metallic flakes went directly to the stomach and passed through the gastrointestinal tract over the next few days. Flakes passed through some animals very rapidly, and they were detectable in the lower intestine and feces the same day they were fed to nutria. However, flakes persisted in most animals for at least a couple days. Flakes appeared to pass through nutria much faster after Day 4. Red flakes had already persisted for several days, but blue flakes fed to nutria on Day 3 also were gone by Day 5. Reasons for this faster rate of passage are unknown. Animals were fed the same diets throughout the test. Although marker treated baits were consumed on the first day, it is possible that animals increased their intake rate as they became more familiar with the marked baits. Rate of passage may have been different when nutria slowly consumed bait throughout the day until it was gone, than when they rapidly ingested all baits placed in their pen.

These markers appear to provide a feasible tool to detect which animals are feeding at bait stations, and possibly to reveal how far they traveled to reach a station(s). Which station(s) an animal visits could be determined by placing baits coated with different colored metallic flakes on each raft. How far animals travel to reach stations could be determined by collecting animals at varied distances from the station and subsequently determining which were marked. Nutria were rapidly marked whenever they ingested bait treated with metallic flakes, but these flakes persisted for only a few days. However, by combining flakes with tetracycline, the animals were marked immediately with one marker and permanently by the other. Therefore, if animals have not ingested treated bait for a few days, which station it was feeding would no longer be detectable but it would be possible to determine whether it had previously fed at a station. Feces left on feeding stations containing metallic flakes with a color indicative of another station would be a clear indicator that animals were visiting more than one station. The rapid rate which flakes passed through some animals in our trial after Day 4 is a concern. Passage rate for nutria foraging on natural plants is unknown, but if rapid, it may reduce the utility of marking animals with metallic flakes.

Nutria response to bait stations during our late spring test was poor. Only 1 of 8 rafts was repeatedly visited. This response, or lack of a response, was probably because nutria had ready access to other food. Native vegetation was actively growing during the study. Nutria are familiar with and readily consume numerous marsh plants (Fuller et al. 1985, Foote and Johnson 1992, Taylor and Grace 1995). Other studies demonstrating strong nutria responses to bait stations after 7 to 10 days of pre-baiting (Evans 1970, LeBlanc 1994) were conducted in areas where preferred native vegetation may have been less abundant. Early studies reported baiting with 0.75% zinc phosphide reduced nutria populations by 95% (Evans 1970). Although the maximum legal concentration for this active ingredient has been reduced to 0.67%, efficacy for removing nutria baited along waterways remains quite high (LeBlanc 1994). Our results indicate that baiting on native marsh during the spring may be less efficacious. Efforts to bait nutria on native marsh would probably be more effective if applied during the winter when native forage is less abundant. Preliminary data from another similar study conducted this past winter, using 8 rafts placed on floating marsh, supports this suggestion (unpublished data). In the more recent study, all of the stations had some nutria activity on them after a couple weeks of pre-baiting.

Sweet potato proved to be the best bait of the three foods tested. It was the most readily consumed bait in the field trial, and captive nutria exhibited a daily preference for sweet potatoes. Nutria regularly consumed almost all available sweet potatoes before eating apples or carrots. Sweet potatoes are generally accessible and their cost is generally less than the other items tested. Sweet potatoes also maintained their bait integrity better than carrots and apples when exposed to normal weather conditions (e.g., heat, rain); carrots and apples both tended to turn soft after a few days in the heat.

The simple stimuli we tested did not appear to serve as strong attractants. However, these trials did indicate the more feasible avenue for developing future attractants. Nutria were not attracted to recorded nutria calls; there was a tendency for them to avoid or not respond during these trials. Nutria are gregarious, forming social groups (Gosling 1977). Perhaps these calls are unique within a social group, helping members to maintain contact, or are used to designate territorial boundaries for intruders. Unique calls, particular if they signify territories, would be difficult to develop as broad-spectrum attractants. Nutria also appeared indifferent to caged conspecifics. Olfactory cues probably provide the best opportunity for developing a workable attractant. Although nutria were not consistently attracted to our test stimuli, they did respond to odors. They followed the odor trail, at least during the first trial, and increased their response times. Most rodent species respond to odors (Mason et al. 1994). We basically used nutria waste as our olfactory attractant. It provided a distinctive odor recognizable to nutria. Whether semio-chemicals or food-based odors will provide the best avenue to develop feasible attractants is unknown. Further experimentation is necessary to identify cues that are consistently attractive to nutria.

Eighty percent of the nutria offered zinc phosphide-treated sweet potatoes died within 24 hours. Although, this is a significant number, we had anticipated 100% mortality. These animals had been pre-baited with sweet potatoes every day for the previous couple months, and prior to treating with zinc phosphide they were readily consuming sweet potatoes daily. Further, this was a stringent acceptance test, as animals were food deprived. Regardless, animals that survived probably did not ingest bait. These results may not be indicative of operational efforts, but it is doubtful efficacy would increase under field conditions. Nutria offered bait under normal field conditions probably will have been pre-baited for only a couple weeks and also will have access to alternative natural foods.

SUMMARY

Nutria foraging causes serious and perhaps irreversible damage to Louisiana coastal marsh (Mach 2002). LDWF wants to reduce populations to stop or at least slow further marsh deterioration. Their goal may be achieved through the incentive program, but alternative approaches to reduce populations are being evaluated.

Zinc phosphide-treated bait works well to control nutria on open waterways (LeBlanc 1994). Our results suggest that baiting efforts on coastal marsh need to be implemented during the winter when native alternative forage is sparse. Bait acceptance, however, may be lower than previously exhibited by nutria on open waterways. Sweet potatoes were more readily accepted by nutria and persisted better under existing weather conditions than did carrots or apples. Tetracycline and ingested metallic flakes showed promise as tools to monitor nutria foraging behavior. Eighty percent of teeth extracted from nutria fed tetracycline treated food were marked after 5 days exposure. The metallic flakes were detectable in animals, but their rapid rate of passage through the digestive system may be a concern. The attractants we tested demonstrated marginal efficacy. Nutria emit audio calls, but recorded calls tended to be avoided and nutria appeared indifferent to live-effigies. Olfactory cues have the greatest potential for developing future attractants.

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